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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

PROGRAM

OF THE

ANNUAL MEETING, DES MOINES, IOWA

DECEMBER 30–31, 1929

IN AFFILIATION WITH SECTION B—PHYSICS—OF
THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT
OF SCIENCE

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
SIX ISSUES EACH YEAR

The American Physical Society

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ANNUAL MEETING, DES MOINES, IOWA, December 30–31, 1929

In Affiliation With

SECTION B—PHYSICS OF

THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The Thirty-first Annual Meeting (the 161st regular meeting) of the American Physical Society will be held in Des Moines, Iowa, Monday and Tuesday, December 30–31, 1929, in affiliation with Section B—Physics—of the American Association for the Advancement of Science. All regular sessions of the Physical Society including the joint session with Section B of the A.A.A.S. will be held at the *Hotel Fort Des Moines*, in the Small Ball Room on the Mezzanine Floor.

General Business Session. The general business session of the American Physical Society will be held at 3 o'clock on Monday afternoon in the Small Ball Room.

Presidential Address. On Tuesday morning at 10 o'clock, December 31, Professor Henry G. Gale will deliver his presidential address on "The Interplay of Theory and Experiment in Modern Spectroscopy."

The Address of the Retiring Vice-President of Section B, Professor P. W. Bridgman of Harvard University, will be delivered on Tuesday afternoon at the joint session with the American Physical Society at the Hotel Fort Des Moines. The subject of his address will be "Permanent Elements in the Flux of Present Day Physics."

Josiah Willard Gibbs Lecture. On Monday afternoon at 4:30 o'clock Professor Irving Fisher of Yale University, will deliver the Josiah Willard Gibbs Lecture on "Application of Mathematics to the Social Sciences.

Opening Session of the A.A.A.S. The opening session of the A.A.A.S. will be held on Friday, December 27 in the Shrine Temple at 8:15 P.M. The

address of the Retiring President of the American Association for the Advancement of Science, Professor Henry Fairfield Osborne, will be delivered at that time.

Other Sessions of the A.A.A.S. The annual Sigma XI lecture will be given Saturday evening, December 28. Dr. George H. Parker will speak on "What Are We About?".

On Sunday afternoon, December 29, at 3 o'clock in the Shrine Temple, Dr. Robert A. Millikan, President of the Association, will deliver an address on "The Alleged Sins of Science."

Dr. A. E. Kennelly will speak before the general session on Wednesday evening, January 1. The subject of his address will be "The Laws of Fatigue, Men and Horses."

CALENDAR

All sessions of the Physical Society and Section B will be held in the Small Ball Room of the Hotel Fort Des Moines.

Friday evening, Dec. 27,	8:15 o'clock	Opening session of the A.A.A.S.
Saturday evening	8:15 "	Sigma Xi lecture by Dr. George H. Parker
Sunday afternoon	3 "	Address by Dr. Robert A. Millikan
Monday morning	10 "	Papers 1–9
Monday afternoon	2 "	Papers 10–17
	3 "	Annual Business Session
	4:30 "	Willard Gibbs lecture by Professor Irving Fisher
Tuesday morning	10 "	Presidential address by Professor Henry G. Gale
Tuesday afternoon	2 "	Joint session with Section B. Vice-Presidential address by Professor P. W. Bridgman; addresses by A. Landé and L. H. Thomas

The supplementary papers Nos. 25–27 may be called for at the end of any regular session.

Wednesday evening	8:15 o'clock	Address by Dr. A. E. Kennelly

Titles and abstracts of the papers to be presented before the Physical Society are given in the following pages. These abstracts have not been corrected by the authors. After correction, they will be published in an early number of the *Physical Review*. Authors should send corrections to the Editor of the *Physical Review* at The University of Minnesota, Minneapolis, Minnesota.

GENERAL INFORMATION

For further information in regard to sessions, meetings, receptions, exhibitions, excursions, etc., see the General Program of the A. A. A. S. which will be available at the registration offices in the Shrine Temple. See also the

Preliminary Announcement of the A.A.A.S., printed in *Science* for November 29.

Headquarters for Physicists. The Hotel Fort Des Moines, 10th and Walnut Streets, has been selected for hotel headquarters for the American Physical Society. (Note that this has been changed from the previous announcement.)

The rates at the Fort Des Moines are:

Single rooms—$2.50 and up
Double rooms—$4.50 and up

Write directly to the hotel or for other accommodations write to Mr. George Hamilton, Des Moines Chamber of Commerce, Chairman for Hotels.

Railroad Rates.—Any person attending the meetings of the A.A.A.S. or its Affiliated Societies, may take advantage of the reduced railroad rates, on the usual certificate plan. The traveler should purchase a one-way, full-fare, through ticket to Des Moines and secure at the same time from the agent a "certificate for the Des Moines Convention of the American Association for the Advancement of Science and Associated Societies." This certificate must be validated at the registration rooms of the A.A.A.S. at the time of the meeting; it will then entitle the owner to a return ticket by the same route without stop-over at half the full fare, within the usual time limits.

Registration. Members should register immediately upon arrival at the registration offices of the A.A.A.S. in the Shrine Temple. It will be necessary to call a day or two later for the validated railway certificate.

A registration fee of one dollar will be charged members of the A.A.A.S. who pay their dues for 1929–30. All others pay two dollars. Registration entitles the person registering to a copy of the General Program and its supplements, to the official badge, to all the general privileges of the meeting and to the validation of one railway certificate.

Membership in the A.A.A.S. Members of affiliated societies are given the privilege of joining the Association at this meeting without payment of the regular entrance fee. Members of any affiliated society simply pay the first annual dues ($5) when they join the A.A.A.S. This payment entitles them to membership for the fiscal year from October 1 to September 30, including a subscription to the official journal, *Science* (or the *Scientific Monthly*, if they prefer), for the calendar year beginning in the fiscal year just defined.

Other meetings of the Physical Society are as follows:

162. February 21–22, 1930. New York.
163. April 18–19, 1930. Washington.
164. June Meeting on the Pacific Coast (Place and date not yet determined).

W. L. SEVERINGHAUS, *Secretary*
Columbia University, New York City

December 13, 1929

PROGRAM

MONDAY MORNING AT 10 O'CLOCK

Small Ball Room, Hotel Fort Des Moines

1. X-ray scattering by mixtures of organic liquids. A. WESLEY MEYER, *University of Iowa.*—The x-ray scattering curves for the following mixtures were obtained; n-ethyl alcohol—methyl cyclohexane, *n*-butyl alcohol—orthodimethylcyclohexane, quinoline-phenol, cyclo-hexane—tetranitromethane and phenol-water. All mixtures but the last one are totally miscible, and it is a solution with either large water content or high phenol content but is an emulsion at other concentrations, but may be dissolved by heating. The resulting curves have peaks to which Bragg's Law is applied to obtain the spacings of the molecules in the cybotactic groups. The results indicate that in every case of solution there is a single type of cybotatic group in which both kinds of molecules participate. The molecular spacing of the group is intermediate between the spacings of the pure liquids and dependent upon the number of each kind of molecule present. In the phenol-water emulsion curves, two spacings were found corresponding to those of saturate phenol water, and saturate water phenol, agreeing with the common belief that the molecules of the constituents of an emulsion do not intermingle, except in large groups, the constituents in this case being the two saturate solutions. The conclusion concerning solutions agrees with that obtained in cases of solid solutions such as alloys.

2. Dependence of viscosity in liquids upon the molecular space arrangement as shown by x-ray diffraction. R. L. EDWARDS, *Miami University* and G. W. STEWART, *University of Iowa.*—It has become possible to make a comparison between the physical condition of a liquid and its viscosity. Twenty-one octyl alcohols made under the direction of Professor E. Emmet Reid of Johns Hopkins were examined by x-rays. The "perfection" of the molecular groups were estimated by the magnitude of the secondary diffraction peaks which evidently depend upon the planar spacing of diffraction centers in the direction of the length of the molecules rather than diametrically. The coefficients of viscosity were obtained by the measurements of Professor E. C. Bingham of Lafayette College. When the OH group is in a fixed position and a methyl group of the octyl alcohol is placed in the possible positions in the molecule, the variation in the coefficient of viscosity varies in a manner similar to that of the magnitude of the secondary peak. The agreement is striking because the variations are large. The interpretation made is in accord with the obvious effects that grouping of molecules to any extent would have. The need of the incorporation of the cybotactic condition or molecular grouping in any theory of viscosity of liquids is emphasized.

3. The extent of noticeable cybotactic condition in a liquid as exhibited by triphenolmethane. G. W. STEWART, *University of Iowa.*—By means of the comparison of the chief x-ray diffraction peak of triphenolmethane in powdered crystal form with that occurring with the liquid, an approximate estimate may be made of the extent of the condition of molecular space grouping throughout the liquid. Areas of the diffraction curves were determined, the experiments being made with thicknesses of material, equal as determined by weight. It was found that the total diffracted energy in the chief diffraction peak of the first order was greater with the liquid than the crystal. Properly interpreted this means that the effective groupings of the molecules in the liquid are approximately of the same extent in the liquid as in a finely powdered crystal. Ignorance concerning the exact nature of the grouping and the structure factors prevent any quantitative comparison.

4. The structure of certain *K* series emission lines. J. VALASEK, *University of Minnesota.*—Recently, Davis and Purks have reported several new satellites near the $K\alpha_1$ and α_2 emission lines of Ni, Cu, and Mo, and $K\beta_1$ of Mo, using a double-crystal spectrometer. The writer has attempted to confirm these results in Siegbahn's laboratory, using a new single-crystal spectrometer designed by Siegbahn. With the slit 0.03 mm wide and the plate at 3 meters, the resolv

ing power in the first order was equal to that of the double-crystal spectrometer in the first order. According to the curves given by Purks, some of the satellites should be perceptible in the first order. Microphotograms were made of the following lines: $K\alpha_1$ and α_2 of Cu, Mo, and Ag, and $K\beta_1$ of Mo. No satellites were found. Lack of time prevented observations in the second order.

5. Fine structure in *K* x-ray absorption spectra. BEN KIEVIT, JR. and GEO. A. LINDSAY *University of Michigan.*—The *K* x-ray absorption spectra of the free elements Ca, Cr, Mn, Co, Ni, Cu and Zn have been photographed and for each of these elements an extended fine structure has been obtained. This fine structure, consisting of six or seven secondary edges, extends over an energy range of some 200 volts. In every instance the element was used as the absorbing screen except in the case of manganese where it was present in the alloy manganin. Indications are that the alloy screen gives the same result as the element alone. A KCl crystal served as reflector to obtain the spectra. Additional exposures were made with copper and with zinc, using the [111] face of calcite as reflector in order to increase the dispersion in this region of shorter wave-lengths. An attempt is made to account for the observed phenomenon on the basis of multiple ionization. The atom absorbs energy sufficient to remove a *K* electron to the first permissible unoccupied orbit and also to eject an outer electron. One is led to the conclusion that probably similar fine structure might be obtained for all elements under suitable conditions.

6. The intensity of reflection of the Kα line of carbon from a quartz surface. ELMER DERSHEM AND MARCEL SCHEIN, *University of Chicago.*—The $K\alpha$ line of carbon ($\lambda = 44.6$A) was reflected from a polished quartz surface and the intensity of the reflected radiation measured for glancing angles of incidence between 1° 15′ and 8°. The apparatus and methods have been previously described (Phys. Rev. **34,** 1015 (1929)). The curve obtained by plotting the experimental values of reflected intensity against glancing angle of incidence is compared with various curves computed from the theoretical value of the index of refraction given by the Drude-Lorentz dispersion formula and values of the absorption coefficient obtained by the extension to this long wave-length region of various well-known empirical formulas relating to x-ray absorption. A calculated curve which is in good agreement with the experimental curve may be secured by the use of a mean of the values of the absorption coefficient for this wave-length in quartz which are given by the different empirical formulas.

7. An x-ray search for the origin of ferro-magnetism. J. C. STEARNS, *University of Denver.*—A sensitive null method, employing two crystals and two ionization chambers, was used to detect any change in the intensity of the Molybdenum K_α reflected from a magnetic crystal when this crystal was magnetized. This method was capable of detecting from 1.0 to 0.1 percent change in the intensity, according to the intensity of the reflected beam. Crystals of magnetite and silicon were used. The change in the intensity of the x-ray beam was computed on the basis of the alteration of the structure factor due to the orientation of the electronic orbits by the magnetic field. The experimental results indicate that there is no change in the reflecting power of crystals of magnetite or silicon steel due to magnetization. It is concluded that electrons revolving in inner orbits within the atom cannot account for ferromagnetism. On the basis of present atomic models and present experimental evidence it appears that the ultimate magnet should be identified with the spinning electron.

8. Magnetic properties of thin films of cobalt. E. P. T. TYNDALL AND W. W. WERTZBAUGHER, *University of Iowa.*—The films are deposited elytrolytically on brass tubes from a 3% solution of cobalt ammonium sulphate with the addition of boric acid. The magnetic properties are largely dependent on the amount of boric acid present in the solution. Films deposited from solutions nearly saturated with boric acid show almost complete magnetic saturation at $H = 200$ gauss ($I_{max} = 1300$ c.g.s. units) and have very high remanence, about 98% of the maximum intensity of magnetization. The reciprocal of the coercive force is roughly proportional to the films thickness for films from 30 to 130 mμ thick, in approximate agreement with the relation previously found for iron (Phys. Rev. **30,** 681 (1927)). Films from less acid

solutions depart considerably from this relation. The properties of the films are undoubtedly partly due to occluded hydrogen, the effect of which is at present being investigated by heating the films.

9. Will the magnetic pole vanish? F. W. WARBURTON, *University of Oklahoma.*—By considering the parallel plate condenser and the long solenoid as sources of uniform electric and magnetic fields respectively, the physical picture of the behavior of dielectrics and of magnetic media (in terms of displacement charge and of the equivalent magnetization current appearing at the respective surfaces) is very evident. The picture is simple and obviates the need of defining and using the fictitious magnetic unit pole even in elementary presentations. E, like B, is dependent on the medium, while D and H are the fields when dielectrics and magnetic media are absent. Non-uniform fields may be considered by the superposition of simpler cases. Were the charge on a condenser rather than the potential difference maintained constant a potential $V' = \int Dds$ would be useful as well as the ordinary potential $V = \int Eds$. Somewhat similarly a scalar magnetic potential $\phi' = \int Hds$, related to ampere-turns, is rather more useful than $\phi = \int Bds$, because it is the current in the solenoid and therefore H, not B, that is externally controlled. H and B can be derived from the corresponding vector potentials, A' and A.

MONDAY AFTERNOON AT 2 O'CLOCK

Small Ball Room

Annual Business Session of the American Physical Society

This session will begin with the reading of the papers as given below. At 3 o'clock the reading of papers will be interrupted for the transaction of the business connected with the Annual Meeting of the American Physical Society. It is probable that the business session will require but a short time, after which the reading of papers will be resumed.

10. Reflection of zinc atoms from NaCl crystals. HAROLD A. ZAHL, *University of Iowa.*—Zinc atoms issuing from a boiler at a temperature of 600°C are in part specularly reflected from a clean cleavage surface of a rock-salt crystal. Measurements, by means of a rotating sectored disc-velocity-filter, of the velocity of the specularly reflected beam show that it contains atoms of but one velocity (or at least a very limited range of velocities). This velocity varies with the angle of incidence as shown below.

θ	vel(m/sec)			Average	$\phi \times 10^{14}$
22.5	763	736	761	753	4.4
45.0	666	672	683	674	12.1
67.5	712	689	695	699	22.2

An equation of the form $\lambda = h/mv = 2d(1 - 2\phi/mv^2 - \cos^2\theta)^{1/2}$ will not represent these results if ϕ is a constant. If it is assumed that ϕ varies with the angle of incidence then of course the equation may be made to fit. Values of ϕ calculated on this assumption are given in the table.

11. Specular reflection of atoms from crystals. A. ELLETT, *University of Iowa.*—The existence of specularly reflected nearly monochromatic beams of atoms and the behavior of these beams on reflection from two crystals in succession (Phys. Rev. **34**, 493, (1929)) is most readily understood as a wave or diffraction phenomenon. Neither the previous observations on cadmium nor those just reported on zinc can be represented by the equation $\lambda = h/mv = 2d(1 - 2\phi/mv^2 - \cos^2\theta)^{1/2}$ if ϕ is supposed to be constant. If it is assumed that ϕ varies with the angle of incidence and this equation used to calculate the appropriate values, we find

θ	22.5°	45°	67.5°
$\phi_m \times 10^{14}$	4.4	12.1	22.2
$\phi_{cd} \times 10^{14}$	4.84	13.2	19.6

The fact that the values obtained run roughly parallel may be significant. These values of ϕ correspond to the existence of a repulsive force acting upon the impinging atom and to values of the refractive index for phase waves $\mu = [1 - 2\phi/(mv^2)]^{1/2}$ less than unity. Both Davisson and Germer and Farnsworth have reported dispersion of the refractive index for electron waves, but the range of variation is much less than that found here.

12. Secondary electrons from contaminated metal surfaces. PAUL L. COPELAND, *University of Iowa.*—Small quantities of grease, or gases, or foreign metal upon a metallic surface have in the past been the cause of many spurious electrical effects. Stuhlmann and Compton cite a spurious contact potential difference of some 60 volts. Using electron reflection as a tool some of the properties of such surfaces have been investigated. The presence of surface impurities on a tungsten wire greatly increases reflection or secondary emission when electrons strike the filament. Surface fields are set up retarding the reflected electron; in some cases the film actually is an insulating layer which breaks down under a potential difference of some 50 volts, which may account for the results of Stuhlmann and Compton.

13. Electron energy losses in mercury vapor. CASTLE W. FOARD, *State University of Iowa.*—An improved magnetic spectrum method was used to determine the energy losses sustained by slow speed electrons in mercury vapor. Electron energies up to 60 volts were used, the main region of interest being from 0 to 25 volts. The energy losses detected, below that required for ionization, were; 4.9, 5.4, 6.7, 7.7, 8.8, 9.8 volts. These correspond to practically all the transitions of a valence electron from the basic $1S$ level up to each of the higher levels to $4P$. No evidence of other losses such as are observed by the photoelectric method was found. At voltages above 10.4, the ionization potential, electrons seem to be able to give up any quantity of energy in excess of that required for ionization, the higher losses being favored. A very interesing loss of 11.07 volts has been found, which has not been recorded heretofore. It begins to be resolved at about 18 volts, and grows steadily with increasing voltage in much the same manner as the 6.7 volts loss. It is thought that this loss involves the displacement of both valence electrons from their normal levels.

14. On the electric arc drawn in vacuum. RAGNAR TANBERG, *Westinghouse Elect. Mfg. Co.* (*Introduced by J. Slepian.*)—In an electric arc drawn in vacuum, the cathode only contributes vapor to the maintenance of the arc, if the arc is of sufficiently short duration. The speed of the vapor emitted from the cathode spot is of the order of $15. \times 10^5$ cm/sec. and the temperature calculated from this molecular velocity is of the order of 500,000°K. Low voltage and high voltage vacuum arc forms have been observed, depending upon the location of the cathode spot relative to the anode. The low-voltage form appears when the cathode spot is so located as to discharge the cathode vapor into the arc stream. The highly ionized cathode vapor in this case prevents the development of negative space charges which otherwise would build up. The high voltage form appears when the path of the cathode vapor does not coincide with the arc stream. Motion of the arc in a transverse magnetic field between solid metal electrodes in a direction opposite to that which would be expected from ordinary electrodynamic considerations has been observed and explained by the bending of their path by the magnetic field and subsequent impingement on the cathode surface of some of the positive ions in the cathode vapor.

15. Voltage-intensity relations of the cadmium spectra. DEVER COLSON, *University of Iowa.*—The critical potentials for different spectrum lines are given by spectrum analysis. Qualitative observations of these critical potentials have been made by Ruark and Chenault and Esclangon and have been used for the differentiation of the different orders of the spark spectra of cadmium. The present work gives more exactly the critical potentials of the more prominent arc and spark lines and traces their behavior as a function of the energy of the impacting electron. The existence of 2^3D orbits suggested but not adopetd by Von Salis is indicated.

16. Absorption of light by flames containing sodium. C. D. CHILD, *Colgate University.*—The intensity of sodium light from a series of flames into which a saturated solution of sodium

chloride is sprayed was found to vary approximately as the square root of the number of flames. As the amount of sodium in the flames is diminished the ratio between the light from several flames and that from one becomes greater. These observations may be explained by assuming; first, that the number of sodium atoms in the flame which are able to emit light in a given direction or to absorb light going in that direction is very much less than the total number of sodium atoms in the flame and secondly that even this limited number is greatly diminished by the process of absorbing sodium light which is going in the direction considered. A possible explanation for these assumptions is that atoms emit light in a direction which bears a definite relation to the orientation of the atom at the time it is emitting the light and absorbs only light which is going in the same direction.

17. The use of homogeneous coordinates in physics and chemistry. HERBERT J. BRENNEN, *Northwestern University.*—It is shown that homogeneous coordinates can be advantageously used in the following cases: 1. A generalisation of the third law of thermodynamics. 2. Equations of state. 3. A generalisation of the phase rule to take account of the change of vapor pressure of a substance, at constant temperature, with the size of the particle. In order to take account of the change of vapor pressure of a substance at constant temperature with the total pressure on the system, the phase rule may be still further generalised by the introduction of a new coordinate the total pressure on the system. 4. The restricted theory of relativity where the four planes are: $X=0$, $Y=0$, $Z=0$ and $\mathfrak{T}=0$, where $\mathfrak{T}$ is the product of the velocity of light and the time. 5. The general theory of relativity where we have four surfaces analogous to the four planes in the restricted theory. Hence, by the use of homogeneous coordinates, four dimensional relativity becomes a problem in a space of three dimensions.

MONDAY AFTERNOON AT 4:30 O'CLOCK

Josiah Willard Gibbs Lecture: "Application of Mathematics to the Social Sciences," Professor Irving Fisher, Yale University.

TUESDAY MORNING AT 10 O'CLOCK

Small Ball Room

Presidential Address

The morning session will open with the Presidential Address by Professor Henry G. Gale on "The Interplay of Theory and Experiment in Modern Spectroscopy."

After the address the regular session for the reading of papers will be resumed.

Paper No. 24 will be read by title.

18. Zodiacal light and magnetic storms. E. O. HULBURT, *Naval Research Laboratory.*—From April, 1853, to April, 1855, Rev. George Jones, U. S. N., observed the zodiacal light every night, weather and other things permitting. A comparison of his record with the Greenwich magnetic storm list gave the following results: In this period there were 26 magnetic storms, or storm groups, and 23 periods of abnormal zodiacal light, 16 of which followed within 3 days after a magnetic storm. 10 storms occurred on dates for which there were no zodiacal light observations, and there were 7 cases of abnormal zodiacal light with no accompanying magnetic storms listed. The abnormalities in the light were mainly fluctuations, and sometimes an unusual brilliance or distribution in the heavens. The correspondence between zodiacal light behavior and magnetic disturbance indicates, but does not prove, that the light comes from particles originating from the terrestrial atmosphere, in accord with the views of Barnard and others. It seems possible to sketch out a qualitative theory by considering the behavior

of the high flying terrestrial ions under the influence of gravitation, light pressure and the terrestrial magnetic field.

19. Changes in the ozone concentration of the atmosphere. RICHARD RUEDY, *Toronto.*—An ozone layer equivalent to 3 mm being situated in the atmosphere above altitude 40 km, that is being contained in a column equivalent to not more than 100 m of air at sea-level, corresponds to a volume percentage of 10^{-3} to 10^{-4}, a value agreeing roughly with that calculated from Nernst's theorem for thermal equilibrium at 6000°. At concentrations of this order, the natural thermal decomposition of O_3 cannot be neglected as has been proposed, when explaining the decrease of O_3 towards the equator. It becomes also apparent in cyclonic, or anti-cyclonic, conditions, owing to the heat radiated to, or from, the troposphere. During the "ultra-violet outburst's" of the sun, as proposed for explaining auroras and magnetic storms, the ozone-building radiations could reach 6 times, the destructive radiations but 1.2 times their stationary values. The daily measurements recently made at Arosa, Marseilles, Oxford, etc. do not exhibit an increase in O_3 for the few days preceding or following the strongest magnetic storms. (October 15, 1926, July 7/8, and October 18, 1928). If the outburst lasted only for one-half hour, the increase would have been smaller than the error of observation (0.01 cm); on the other hand, increases by 0.04 cm are observed in the absence of magnetic storms.

20. Electrodynamic damping in pulsating stars. ROSS GUNN, *Naval Research Laboratory, Washington, D. C.*—Small radial pulsations of stars are shown to be highly damped by electrodynamic forces when the star has a magnetic field. The author's theory of the permanent magnetic field of the sun indicates that the field is produced by regenerative means which is triggered off by a small initial field. The small initial field probably arises from the rotation of the star combined with a separation of charge, although it may conceivably arise in other ways. Thus rotating stars will have a magnetic field and cannot pulsate, and conversely stars which pulsate have no magnetic field and do not rotate. Cepheid variables are observed to pulsate and therefore have no magnetic field and do not rotate. This is in keeping with the idea that Cepheid variables, being youthful giants, are so large that they would be unstable under rotation. These considerations appear to remove the difficulties encountered by Eddington in his detailed theory of star pulsations.

21. The analysis of cosmic-ray observations. LE ROY D. WELD, *Coe College.*—Millikan and Cameron find evidence of several distinct absorption coefficients for the cosmic rays in deep lakes, suggesting a spectrum of definite wave-lengths. In this paper, a general method of least-square adjustment of non-linear observation equations is adapted to the analysis of the cosmic-ray absorption curve, in order to determine the most probable values of the two constants for each component of the radiation.

22. Mass-weight ratio of metals under strain. P. I. WOLD, *Union College.*—The late Dr. Charles F. Brush conducted work for years on the mass-weight ratio of metals. One of his methods of experimentation consisted in weighing certain alloys while they were subjected to very considerable pressure. He found losses in weight amounting to as much as one part in 40,000. Measurements have been carried on for the last two years on alloy specimens, which he had prepared, to see if independent observers could reproduce his results. On such specimens changes amounting to about one part in 150,000 were obtained. The curves of weight against pressure show the same characteristics as obtained by Dr. Brush. While the changes are small, they are substantially larger than can be ascribed to the errors of the balance or to temperature changes.

23. The surface tension of molten glass at temperatures near the melting point. W. B. PIENTENPOL AND H. H. SCOTT, *University of Colorado.*—A new method has been devised by which the surface tensions of a number of glasses of different composition have been determined throughout a range of temperature of approximately 200°C. just above the softening points. The method is termed "The Bulb Method" and is similar to the soap bubble experiment in which the excess of pressure within the bubble can be balanced against a small head of liquid in a manometer. It was found that the weight of the glass bulb needed to be considered and a

formula is developed giving the relation between surface tension and pressure in which the correction factor is introduced. Throughout the range to which the method is applicable, it is found that the surface tension of glass varies but slightly with temperature. The magnitude of the surface tension for different glasses is of the order of 250 to 350 dynes per cm.

24. Thermal expansion of lead. PETER HIDNERT AND W. T. SWEENEY, *Bureau of Standards.*—Data by Hidnert and Sweeney on the linear thermal expansion of one sample of cast lead and various lead-antimony alloys between 20 and 60°C were published in 1924 by Vinal, "Storage Batteries." Since then additional determinations were made on three samples of cast lead over various temperature ranges between 20 and 300°C. The following results were obtained:

Sample[1]	Lead content Percent	Average coefficients of linear expansion per Degree Centigrade: 20 to 60°C. $\times 10^{-6}$	20 to 100°C. $\times 10^{-6}$	20 to 200°C. $\times 10^{-6}$	20 to 30°C. $\times 10^{-6}$	Difference in length before and after Expansion test Percent
1215[2]	99.8	29.0	28.9	29.7	30.9	−0.01
		——	28.8	29.4	31.0	.00
1144	99.9	28.3	28.6	29.5	31.2	.00
1001[3]	——	29.2	29.6	31.2	32.5	+ .02

[1] Samples 1215 and 1144 were cast in sand molds, and sample 1001 in a pre-heated steel mold.

[2] Values given on second horizontal line were obtained on a second test.

[3] Sample 1001 cast from same ingot as sample 1215.

The differences obtained in the coefficients of expansion are evidently due to variations in the methods of casting.

TUESDAY AFTERNOON AT 2 O'CLOCK

Small Ball Room

Joint Session of the American Physical Society With Section B of the A.A.A.S.

The session on Tuesday afternoon, December 31, at two o'clock, will be in charge of the officers of Section B—A.A.A.S. Professor C. E. Mendenhall of the University of Wisconsin, Vice-President of Section B will preside.

1. Permanent Elements in the Flux of Present Day Physics. Address of the Retiring Vice-President for Section B—A.A.A.S., P. W. Bridgman, Harvard University.

2. Polarization of Matter Waves. A. Landé, University of Tübingen (Germany), (Ohio State University 1929–1930).

3. The Wave Mechanics of Collision Processes. L. H. Thomas, University of Cambridge (England), (Ohio State University, 1929–1930).

SUPPLEMENTARY PROGRAM

When two or more papers are offered by the same member, one only of these papers will be assigned a place on the regular program, while the others will be placed in a supplementary program, to be called for if time permits.

25. Two different types of association of alcohol molecules in the liquid state. G. W. STEWART. *University of Iowa.*—By x-ray diffraction studies of liquid alcohols, including twenty-one octyl alcohols, eleven primary n-alcohols, and nine additional isomers of primary normal alcohols, evidence is obtained of two types of association of molecules. When the OH group is attached to the terminal carbon atom or the one adjacent thereto, the molecules are associated primarily in pairs with the OH group adjoining and the median lines of two chains in the same line. At the same time there is a more or less orderly lateral arrangement of these pairs of OH groups. When the OH group is attached to any other carbon atom in the chain, then the double molecules disappear and the association is side by side. There is no exception to these conclusions in the liquids studied.

26. On the theory of the solar corona. E. O. HULBURT, *Naval Research Laboratory.*—The outer atmosphere of the sun is assumed to be composed mainly of charged particles, which are actuated by gravitation, radiation pressure and the magnetic field of the sun. By distillation along the lines of magnetic force the particles collect in the lower latitudes of the solar outer atmosphere and by their diamagnetism and drift currents reduce the magnetic field approximately to zero in this region, leaving a stray field at the poles. Thus the coronal streamers, prominent during sun-spot minima, are regarded as owing their form to the magnetic field of the sun. Whereas the wide-spreading structureless coronal luminosity expending out from the lower latitudes is due to an accumulation of ionization which reduces the magnetic field to a low value and permits the radiation to blow the particles out to great distances. During maximum solar activity there is sufficient ionization of the outer atmosphere to reduce the magnetic field to a low value even at the poles, and hence the outer atmospheric spray extends roughly equally in all directions, in accord with the appearance of the corona.

27. Resistance of an electrolytic conductor at various frequencies. D. E. RICHARDSON, *University of Chicago.* (*Introduced by J. Barton Hoag.*)—The resistance of a conductor, as defined by the ratio of electrical energy converted into heat and the square of the current, is a function of the frequency of the current because of the non-uniform current density throughout the cross-section of the conductor. Classical electrical theory offers an equation for this skin effect. This has been verified for metallic conductors for frequencies up to one megacycle. Using a calorimetric method, the equation is now verified in a particular case of electrolytic conduction (30% solution of H_2SO_4) for frequencies up to eight megacycles (37 m). It is concluded that the resistivity of this electrolytic conductor is independent of the frequency up to eight megacycles, since this assumption was made in the derivation of the equation. Measurements of the currents were made by comparing photometrically the intensities of two filaments, one carrying the high frequency currents, the other direct current.